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# The impacts of petroleum price fluctuations on income distribution across ethnic groups in Malaysia



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## ABSTRACT

Crude oil price hikes have compelled governments of developing countries to let domestic prices of energy increase. Fiscal priorities made it impossible to fully compensate the hikes by raising energy subsidies. This paper examines the potential impacts of a limited deregulation of the petroleum price on the income distribution in Malaysia, paying specific attention to differences in impacts on major ethnic groups. We introduce an extended social accounting matrix (SAM) model, which not only incorporates substitution possibilities among production inputs and consumption goods, but also allows for the exogenous determination of the price of intermediate inputs. The results of simulations indicate that distributional impacts of rising petroleum prices tend to be regressive, affecting poor people more severely than richer people. All ethnic groups experience income loss with the real incomes of Malay households (which are relatively poor, on average) more than the Chinese and Indian households (which are the generally richer).

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## 1. Introduction

Recently, concerns have risen about the distributional implications of environmental policies (see, for example, Morilla et al., 2007; Kerkhof et al., 2008; Vona and Patriarca, 2011; Bouvier, 2014; Taylor et al., 2016). Although economic policies are commonly known to be economically efficient instruments for achieving environmental goals, they may not be sustainable policies if income inequality is seriously affected. In countries where the majority of the population depends greatly on petroleum for their livelihood, a policy of subsidizing petroleum products has been pursued to keep prices well below the international levels. This paper deals with distributional impacts of policies for pricing natural resources.

The recent world price of crude oil shows a downward trend, drops significantly from 96.26 USD per barrel in 2014 to 52.43 USD per barrel in 2015 (Organization of the Petroleum Exporting Countries, 2015). Investigating the consequences of price dropping may not be highly relevant for equity-efficiency policies because it tends to promote greater equality in income distribution and improves fiscal balance. The similar conclusion is observed in this paper (see Section 5). This is the main reason why the literature on the distributional implications of energy

price has been devoted to the price hikes (see for example, Jiang et al., 2015; Moshiri, 2015). Moving further forward, the world price of crude oil is expected to increase again as what had observed in the periods 2005–2013, reaching 110 USD per barrel by 2020 (see Organization of the Petroleum Exporting Countries, 2014).

Substantial increases in world prices raise a fundamental question: should domestic prices of petroleum products increase as well, or should government budgets be used to make up for the larger differences between international and domestic petroleum prices? The purpose of this paper is to examine the distributional implications of rising petroleum price in Malaysia. Economic efficiency considerations prescribe that domestic prices are not regulated and kept in line with world prices, inducing more supply and less demand. Equity considerations, however, usually focus on the unfavorable effects of deregulation of petroleum prices on income distributions. Households in lower quantiles of these distributions suffer more, because they generally spend above-average fractions of their budgets on energy (see, for example, Saboohi, 2001; Silva et al., 2009). These conflicting recommendations ask for careful analyses of the extent to which income equality will be affected by energy price policies, taking country-specific issues into account.

Malaysia is chosen as a case in point for two main reasons. First, petroleum price hikes between 2007 and 2008 have led to the significant energy price reforms in Malaysia. The magnitude of subsidies of petroleum products expressed as a share of gross domestic product (GDP) doubled from 0.7% in 2001 to 1.4% in 2007 (Ministry of Finance,

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various years). Given the world price level of 2008, the Malaysian government would have had to increase its subsidies to a level equivalent to 2.3% of GDP if it had wanted to stick to the then prevailing policy.<sup>1</sup> This was considered unsustainable, as a consequence of which the government raised the domestic price of petroleum eight times in 2008. Thus, deregulation of petroleum prices may have significant implications for income inequality across households.

Second, the distributional implications are detailed across ethnic groups that have several unique features. Malaysia is characterized by three major ethnic groups (the Malays, Chinese, and Indians) and changes in their relative household incomes have been included explicitly in the national development plan. Income inequality between ethnic Malays, Chinese and Indians has been a concern over the past four decades, especially after ethnic riots in May 1969 (e.g., Heng, 1997; Shari, 2000; Faaland et al., 2003). The riots highlighted the dangers that can arise in a multiracial society when ethnic prejudices are exacerbated by income disparities (e.g., in 1970, incomes per capita for Chinese and Indians were 126% and 76% higher, respectively, than that of Malays). Economic reforms and growth have improved the incomes of all Malaysians, but the income gaps remain large. In 2000, the per capita income of Chinese and Indians was still 74% and 36% larger, respectively, than that of ethnic Malays (Saari et al., 2014). The unique case about Malaysia is that its income distribution differs from that of other developing economies such as Vietnam (van de Walle and Gunewardena, 2001) and Chile (Agostini et al., 2010), in which minority groups earn lower incomes.<sup>2</sup> Hence, the distributional effects across ethnic groups of changes in domestic petroleum prices are the focal topic of this paper. Insight into such distributional effects is highly relevant for policy makers to determine whether the deregulation of domestic petroleum prices has regressive or progressive impacts and if necessary, mitigation measures are required.

The impacts are analyzed by using a social accounting matrix (SAM) model, which covers the entire economy and quantifies linkages between several production sectors and households of various ethnic groups. This study makes two contributions to the international literature on the link between energy prices and income. First, it revives the analysis of distributional aspects of energy price policies. Brada (2013), for example, finds that positive movements in energy prices correlate negatively to changes in the share of labor in income. These aspects received relatively much attention in energy studies about three decades ago, in particular during the oil price hikes (see, for instance, Berndt and Morrison, 1979; Behrens, 1984; Common, 1985), but were superseded in more recent studies by a focus on the aggregate income effects of changes in energy prices (see, for instance, Kratena, 2005; Welsch and Ochs, 2005; Neuwahl et al., 2009). Moreover, our model and dataset do not only classify households according to ethnicity, but also make a distinction between their location in rural or urban areas. Second, we also refine the common static SAM-based models by specifying substitution possibilities among inputs into production processes, as well as among household consumption products. To capture substitution effects following changes in relative prices, elasticities of substitution are first calibrated on the benchmark dataset in the SAM and then incorporated into the SAM model.

The next section discusses briefly petroleum price reforms in Malaysia along with the consumption shares of energy and non-energy products by ethnic groups. Section 3 explains technical details of the standard SAM model and its extension to account for substitution effects as a consequence of changes in relative prices (and the actual procedure to determine these substitution elasticities). Section 4 details

how shocks in petroleum prices are introduced in our analysis. Section 5 presenting our main findings and discusses the distributional impacts of increases in petroleum prices. Section 6 concludes by providing some methodological remarks.

## 2. Petroleum Price Reforms and Consumption Shares

In Malaysia, petroleum subsidies and price controls have long been a feature of the economy. Beginning in 2007, world price of crude oil entered their most volatile period in the history, increased by 36.7% to reach 94.45 USD per barrel in 2008 (see Table 1). This has led to the most significant petroleum subsidy reforms in Malaysia, which consequently push up the domestic retail prices. In 2008, diesel and gasoline prices became 35% and 15% more expensive, while liquid petroleum gas (LPG) decreased marginally by 2.9%. The large differences between the price changes of diesel and gasoline on the one hand and the world price for oil on the other hand, clearly reflect the consequence of petroleum subsidies, although the subsidy rates have been reduced over time. Much more recent oil price hikes have compelled the Malaysian government to reconsider the petroleum subsidies, as part of ongoing economic reforms to rebalance fiscal priorities and to remove efficiency-reducing market distortions.

The increases in the world price of crude oil are substantial for the periods 2005, 2008 and 2011 which accelerated by 40.5%, 36.7% and 38.7%, respectively. For the similar periods, the average domestic petroleum prices are enlarged only by 12.2%, 14.8% and 6.7%, respectively. The level of domestic petroleum prices in 2008 not only shows the highest increment but also the government has adjusted the prices as many as eight times, implying the price reforms had taken extensively in this period. This justifies our choice to estimate how the increase in petroleum prices in 2008 has impacted inequality across ethnic groups.

Deregulation of petroleum prices may significantly reduce real incomes of Malaysian households, because consumption of products that require a lot of energy constitutes a considerable share of household budgets. Table 2 presents the consumption shares on energy-intensive and less energy-intensive products for each ethnic group which are derived from the 2000 SAM (see Saari et al., 2014). For each product, energy intensity is defined as the percentage petroleum product embodied in the total output. Data that used to estimate the consumption by each ethnic group in the SAM is taken directly from the household expenditure survey (see Department of Statistics Malaysia, 2001b). Overall, the shares for consumption of energy-intensive products are higher for the ethnic Malays (23.8% of their budget) than for Chinese (16.0%) and Indians (16.5%). Among the energy-intensive products, the difference in consumption shares that is most remarkable is for petroleum products. For the ethnic Malays, this budget share is approximately twice as large as the budget shares of the Chinese and Indians. There are several factors that may explain the variations in the consumption behavior of each ethnic group. For example, consumption on petroleum products strongly relates to private vehicle ownership and Vien and Sadullah (2005) show that the size of families is one of the main determinants for private vehicle ownership in Malaysia. Our dataset shows that the average family sizes for the

**Table 1**  
Movement of petroleum prices, 2004–2008.

	Gasoline (MR/l)	Diesel (MR/l)	LPG (MR/l)	Crude oil (USD/barrel)
A. Average price movements				
2004	1.37	0.81	1.43	36.05
2005	1.50	1.08	1.47	50.64
2006	1.90	1.58	1.80	61.08
2007	1.90	1.58	1.80	69.08
2008	2.18	2.13	1.75	94.45

Sources: Organization of the Petroleum Exporting Countries (2010) and Ministry of Domestic Trade, Co-operatives and Consumerism (2010).

<sup>1</sup> In Malaysia, petroleum products are taxed according to an automatic pricing formula. The sales tax on petroleum products is reduced to offset the differences between world prices and retail prices set by the government. When the difference between the world prices and final retail prices exceeds the sales tax, the tax is completely eliminated and the products are explicitly subsidized.

<sup>2</sup> In 2005, ethnic Malays made up 61% of the population, while people of Chinese descent accounted for 26%, Indians for 8% and other ethnic minorities for 5%.

**Table 2**

Budget shares for consumer items and per capita income in 2000.

	Energy-intensity	Malays	Chinese	Indians	Others
<i>A. Energy-intensive products (%)</i>					
Fishing	17.26	2.89	2.04	2.52	1.84
Electricity and gas	8.36	1.05	4.48	0.33	10.03
Transport services	7.21	4.76	1.96	3.08	2.32
Clay products	7.74	0.06	0.05	0.11	0.01
China, glass and pottery	6.76	0.02	0.01	0.01	0.01
Petroleum products	6.85	12.23	5.39	6.20	2.90
Industrial chemicals	5.36	0.11	0.06	0.09	0.09
Oils and fats	4.02	2.64	2.00	4.11	2.08
<i>B. Less energy-intensive products (%)</i>					
Foods and non-alcoholic beverages	1.03	10.63	8.39	13.00	8.83
Alcoholic beverages and tobacco	0.41	0.60	1.23	1.51	1.27
Clothing and footwear	0.63	5.13	3.37	4.58	3.58
Housing and water	1.34	3.21	2.81	2.52	3.42
Furnishings, household equipment and maintenance	0.28	2.48	1.77	1.73	1.06
Health	0.41	2.23	2.83	4.45	0.88
communication	0.09	11.62	5.04	6.65	1.89
hotels & restaurants	0.86	11.08	14.03	15.83	1.40
Miscellaneous goods and services	0.61	29.26	44.52	33.27	58.40
Per capita income (Malaysian Ringgit, MR)		4784	8801	7380	11,640

Source: derived from the household expenditure survey 1999/2000 (see [Department of Statistics Malaysia, 2001b](#)).

Malays, Chinese and Indians are 4.8, 4.2 and 4.5 respectively. Another remarkable difference in the consumption shares concerning the electricity and gas. The budget share of the Chinese is three and four times as large as the budget shares of the Malays and Indians, respectively. Analyzing the differences in the consumption behavior is beyond the scope of this study because it requires for a specific modeling development and our available dataset is not measure everything perfectly.

The increase in petroleum prices will affect households also indirectly through consumption of non-petroleum products. This is because also non-petroleum products will become more expensive when the cost of the energy that is needed to produce these products will rise. The share of the income that is spent on petroleum and other energy-intensive products varies across ethnic groups. The effects of changing prices are thus likely to have different implications across ethnic groups, too. In particular, the ethnic group with the lowest per capita income (i.e. the Malays) spends the largest share on energy-intensive products and may thus be seriously affected from the deregulation of domestic petroleum prices. The next section discusses the methods to measure the distributional impacts of deregulation of petroleum prices.

### 3. The Extended Social Accounting Matrix Model

A social accounting matrix (SAM) is a comprehensive data framework that has been widely applied for analyses of income distribution and poverty (see, for example, [Thorbecke and Jung, 1996](#); [Khan, 1999](#); [Llop and Manresa, 2004](#); [Civardi et al., 2010](#); [Rada, 2010](#); [Saari et al., 2015](#)). Applications of SAM models for analyzing the distributional impacts of environmental and energy policies are well documented (see, for example, [Resosudarmo and Thorbecke, 1996](#); [Morilla et al., 2007](#); [Hartono and Resosudarmo, 2008](#); [Akkemik, 2011](#)). In this paper, we propose an extended SAM model which is introduced after presenting the standard model.

#### 3.1. The Standard Quantity and Price Model

A SAM contains data from national accounts, but typically incorporates much more detail regarding monetary flows among sectors, between sectors and several types of households and the government, and between these domestic entities and the rest of the world. In a SAM, incomes are recorded in rows (*i*), while expenditures are contained in columns (*j*). The totals for rows and corresponding columns of the matrix must be identical, consistent with the accounting principle that the sum of incomes equals the sum of expenditures for

each single account. The Malaysian SAM that we use in this study was developed [Saari et al. \(2014\)](#) for the benchmark year 2000 and the basic structure of the SAM is outlined in [Table 3](#).

Our SAM contains 92 production sectors, 27 factors of production (25 types of labor inputs and two capital inputs), and 10 institutions (9 household groups and companies). For labor inputs, the first distinction is made between citizen and non-citizen workers. Second, the citizen workers are further categorized according to their ethnicity: Malays, Chinese, Indians, and a group of minorities, labeled as Others. Third, a distinction is made based on skills (low, medium, high), according to educational attainment. Finally, workers are classified according to whether they are located in a rural or an urban area. Hence, we end up with 25 types of workers (non-citizens, plus citizens of one of four ethnic groups, three skill levels and two location types). Capital inputs are split into capital inputs owned by households and corporate capital inputs.

The classification of households closely follows the classification of labor, with the exception of skill types, for which we do not have data. This leads to nine household groups (four ethnic groups  $\times$  two geographical areas + one non-citizen group). The remaining accounts of the SAM (government, consolidated capital, the current account, the capital account for the rest of the world, and indirect taxes) have been aggregated into a single account.

Our analysis is based on the SAM for 2000, which is the latest database that available for Malaysia. During the study period, the more recent input-output table, household income survey (HIS) and household expenditure survey (HES), which are the main dataset for the construction of the SAM, are not available. This implies that the stability of SAM coefficients is a matter of concern when addressing questions related to much more recent years. We have to assume that input-output relations, income distributions and consumption structures have remained stable. To verify these assumptions, we analyze stabilities of three major subset coefficients in the SAM using the more recent dataset that are currently available. First, we have measured the stability of input-output coefficients between the periods 2000 and 2005 by following the approach of [Dietzenbacher and Hoen \(2006\)](#) and [Wood \(2011\)](#). Using the root mean squared error (RMSE) measure, the average forecast error for the five year lags ranges from the lowest 0.2% to the highest 12.7%.<sup>3</sup> Second, we also measure the

<sup>3</sup> For other economies, most national statistics offices produce input-output table with a lag time of three-four years. The average forecast error for three year lags that documented in [Wood \(2011\)](#) ranges from 5% to 15% while it ranges from 1.0% to 6.1% for four year lags that reported in [Dietzenbacher and Hoen \(2006\)](#).



**Table 3**  
Schematic representation of endogenous and exogenous accounts in the SAM.

			Endo. accounts			Exo. accounts	Total
			(1)	(2)	(3)	(4)	(5)
Incomes ( <i>i</i> )	Production (92 sectors)	(1)	$T_{11}$	0	$T_{13}$	$x_1$	$y_1$
	Factor of production (27 factors)	(2)	$T_{21}$	0	0	$x_2$	$y_2$
	Institutions (9 households and companies)	(3)	0	$T_{32}$	$T_{33}$	$x_3$	$y_3$
	Exogenous account (aggregated)	(4)	$I_1$	$I_2$	$I_3$	$t$	$y_4$
	Total	(5)	$y_1$	$y_2$	$y_3$	$y_4$	
$T_{11}$	Intermediate input requirements		$x_1$	Final demands (government consumption, investment and exports)			
$T_{13}$	Consumption of domestic products		$x_2$	Factor income received abroad			
$T_{21}$	Generation of value added		$x_3$	Domestic and international transfers			
$T_{32}$	Factor income distribution		$t$	Imports, taxes and balance of payments			
$T_{33}$	Inter-institutional income transfer		$y_1$	Total output ( $=y_1$ , total input)			
$I_1$	Imports and taxes paid by production sectors		$y_2$	Total factor income ( $=y_2$ , total factor outlay)			
$I_2$	Factor income paid abroad		$y_3$	Total income ( $=y_3$ , total expenditure)			
$I_3$	Consumption of imports, saving and taxes paid by households		$y_4$	Total leakage (= total injection)			

changes in income distribution between the periods 2000 and 2005 across the major ethnic groups, using two different sets of HIS. Results show that the changes in income shares between these periods are: 1% for the Malays (income shares in 2000 and 2005 are 47% and 46%, respectively); –5% for the Chinese; and –2% for the Indians. This consistent with the reported Gini coefficients which show marginal changes, increases by 4.4% for the Malays, 2.8% for the Chinese and 2.9% for the Indians (see [Economic Planning Unit, various years](#)). Empirically, the fixed income distribution also has been justified to some extent (see for example, [Kraay, 2006](#); [Loayza and Raddatz, 2010](#)). Third, we have used two different sets of HES for the periods 2000 and 2005 to measure the stability of consumption structure. Results show that the household consumption on the major expenditure items for the periods 2000 and 2005 show a very constant share (see [Department of Statistics Malaysia, 2001a,b, 2006](#)). Consumption share for housing expenditure is reduced by 1%, which is offset by the increased in transport expenditure and consumption share for other commodities is remaining unchanged. Altogether, the structures of production, income and consumption in 2000 SAM are fairly stable to be used for the recent price shocks.

In our model, production activities (sectors), factors of production, and institutions (i.e. households and companies) are considered as accounts for which the cell values will be determined *endogenously*, as a function of SAM-based coefficients and values for the exogenous accounts. The remaining (aggregate) account is *exogenous*.<sup>4</sup> For the purpose of multiplier modeling, the transactions (matrices  $T$  and vectors  $I$ ) were converted into corresponding average expenditure propensities (i.e. matrices  $A$  and vectors  $a$ ).<sup>5</sup> Define

$$T = \begin{bmatrix} T_{11} & 0 & T_{13} \\ T_{21} & 0 & 0 \\ 0 & T_{32} & T_{33} \end{bmatrix}, I = \begin{pmatrix} I_1 \\ I_2 \\ I_3 \end{pmatrix}, x = \begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix}, y = \begin{pmatrix} y_1 \\ y_2 \\ y_3 \end{pmatrix}. \quad (1)$$

The average expenditure propensities consist of two parts: (i) those corresponding to the endogenous accounts,  $A = T\hat{y}^{-1}$ , and (ii) those corresponding to the exogenous account,  $a' = I'\hat{y}^{-1}$ . The average propensities in  $a$  are normalized costs (e.g. per unit of production) that “leak” out as expenditure into any one of the five exogenous accounts. In our model, these leakages include imports and sales taxes.

<sup>4</sup> SAM models provide flexibility in assigning accounts to either the group of endogenous or the group of exogenous accounts. The choice depends on the type of analysis.

<sup>5</sup> Matrices will be denoted by bold capital symbols. Vectors are columns and represented by lowercase bold symbols. Scalars are indicated by lowercase italics. A prime denotes transposition and a hat refers to a diagonal matrix with the elements of a vector on the main diagonal.

In the standard SAM quantity model, the income levels  $y$  in the endogenous accounts are obtained by post-multiplying the SAM inverse matrix  $M = (I - A)^{-1}$  with a vector of exogenous income levels  $x$ :

$$y = Ay + x = (I - A)^{-1}x = Mx \quad (2)$$

where  $I$  is the identity matrix of appropriate dimensions and  $M$  is the multiplier matrix. Its typical element  $m_{ij}$  indicates the total income effect for the production sectors, factors of production or institutions in row  $i$  of a unit increase in the exogenous income  $j$ . In the static model, quantities can vary, but prices are assumed to remain fixed. This assumption basically implies that sufficient excess capacity and unused resources exist to meet additional demand without an upward pressure on prices. Furthermore, expenditure propensities are assumed not to change with income, which yields linear relationships between the income levels of the exogenous and endogenous accounts.

The dual of this quantity model is a cost-push price model. The model is useful for the analysis of price shocks, in situations in which it is reasonable to assume that prices vary while quantities are fixed (i.e. demand is assumed to be perfectly inelastic to prices).<sup>6</sup> This model can be written as (see [Miller and Blair, 2009](#)):

$$p = A'p + a = (I - A')^{-1}a = M'a. \quad (3)$$

Here,  $p$  is the vector of price indexes for the endogenous accounts,  $A'$  is the transposed matrix of average expenditure propensities and  $a$  is the vector of average expenditure coefficients expressing the per unit leakage. These leakages represent exogenous costs to the endogenous accounts and are the sums of the five exogenous cost components: payments to the government, savings, imports, investments abroad and indirect taxes. The base-year solution corresponds to the SAM from which the coefficients were obtained. As a consequence, all prices are equal to unity.<sup>7</sup> A price increase in one or more of the exogenous accounts (e.g. imports) will lead to higher values of  $a$ , which will then be reflected in higher prices for the endogenous accounts.

<sup>6</sup> Applications of SAM models to study price formation are rather rare. The first (and as far as we know the only) attempt to analyze cost-push effects using a SAM price model is [Roland-Holst and Sancho \(1995\)](#). Extensive discussions about properties of price and quantity input-output models can be found in [Oosterhaven \(1996\)](#) and [Dietzenbacher \(1997\)](#).

<sup>7</sup> All coefficients are obtained from a consistent SAM. For any endogenous account, the coefficients therefore sum to one. In mathematical terms, we have for Eq. (3)  $A'e + a = e$ , where  $e$  indicates the summation vector consisting of ones. An immediate consequence is that  $p = e$ .

For the SAM in Table 3, Eqs. (2) and (3) are partitioned as follows.

$$\begin{bmatrix} \mathbf{y}_1 \\ \mathbf{y}_2 \\ \mathbf{y}_3 \end{bmatrix} = \begin{bmatrix} \mathbf{A}_{11} & 0 & \mathbf{A}_{13} \\ \mathbf{A}_{21} & 0 & 0 \\ 0 & \mathbf{A}_{32} & \mathbf{A}_{33} \end{bmatrix} + \begin{bmatrix} \mathbf{x}_1 \\ \mathbf{x}_2 \\ \mathbf{x}_3 \end{bmatrix} \quad (4)$$

$$\begin{bmatrix} \mathbf{p}_1 \\ \mathbf{p}_2 \\ \mathbf{p}_3 \end{bmatrix} = \begin{bmatrix} \mathbf{A}'_{11} & \mathbf{A}'_{21} & 0 \\ 0 & 0 & \mathbf{A}'_{32} \\ \mathbf{A}'_{13} & 0 & \mathbf{A}'_{33} \end{bmatrix} \begin{bmatrix} \mathbf{p}_1 \\ \mathbf{p}_2 \\ \mathbf{p}_3 \end{bmatrix} + \begin{bmatrix} \mathbf{a}_1 \\ \mathbf{a}_2 \\ \mathbf{a}_3 \end{bmatrix} \quad (5)$$

In the quantity model (4),  $\mathbf{y}_1$  refers to production output,  $\mathbf{y}_2$  denotes income levels of factors of production and  $\mathbf{y}_3$  represents incomes of institutions. In the price model (5),  $\mathbf{p}_1$  refers to the price indexes of products,  $\mathbf{p}_2$  represents price indexes of factors of production (for example, the wage rate of high-skilled rural Malays) and  $\mathbf{p}_3$  indicates price indexes for the expenditures of households and companies. The linkages among the SAM accounts play an important role in the price model: an increase in the price of imports, for example, induces producers using these imported products to set higher prices for their outputs. This leads to further price increases, because their outputs are used as intermediate inputs ( $\mathbf{A}_{11}'$ ) and bought by households ( $\mathbf{A}_{13}'$ ). These households will ask higher prices for the factors of production they supply ( $\mathbf{A}_{32}'$ ), leading to further price changes. The solution to model (5) is the set of equilibrium price indexes associated with any set of exogenous per unit costs  $\mathbf{a}$ .

### 3.2. The Model with Price-induced Substitution Effects

To study the effects of an increase in the price of petroleum products in Malaysia, the standard price model described in the previous section is not helpful. Petroleum prices are endogenously determined in the standard SAM price model, while we consider exogenous changes in this price as a consequence of changing world prices and changing public policies regarding taxes and subsidies. Another less desirable implication of the standard model is that petroleum price hikes would not have any impact on product-specific demand for intermediate inputs and for consumption purposes, although prices of petroleum-intensive products will increase relative to those of non-petroleum-intensive products. We will first discuss the modifications needed to allow for substitution and then turn to the problem of fixing a price related to part of the endogenous accounts.

In our extended model, we allow for price-induced substitution: a new set of prices leads to a new set of average expenditure propensities.<sup>8</sup> The new average expenditure propensities can then be applied to calculate impacts on the income levels in other endogenous accounts, using the quantity model. This subsection explains our procedures for the generation of the new average expenditure propensities in the price-induced model.

In line with earlier work by Kolk (1983), Meyer (1989) and Kratena (2005), the substitution possibilities are incorporated by endogenously specifying changes in input demand and consumption of commodities as functions of changes in relative prices. We can model substitution in quantities as a consequence of relatively small price changes as in Eq. (6)

$$\bar{\mathbf{A}} = \begin{bmatrix} \bar{\mathbf{A}}_{11} = \mathbf{A}_{11} \otimes (\mathbf{E} + \bar{\boldsymbol{\Sigma}} \hat{\delta}_p \mathbf{E}) & 0 & \bar{\mathbf{A}}_{13} = \mathbf{A}_{13} \otimes (\mathbf{E} + \bar{\boldsymbol{\Theta}} \hat{\delta}_p \mathbf{E}) \\ \bar{\mathbf{A}}_{21} = \mathbf{A}_{21} \otimes (\mathbf{E} + \bar{\boldsymbol{\Phi}} \hat{\delta}_p \mathbf{E}) & 0 & 0 \\ 0 & \mathbf{A}_{32} & \mathbf{A}_{33} \end{bmatrix} \quad (6)$$

<sup>8</sup> The propensities change as a consequence of changes in relative prices that are not related to changes in endogenous prices, but only to exogenous shocks in world prices and subsidy rates. In this sense, our model is different from full-fledged computable general equilibrium (CGE) models. In a CGE model, the changes in quantities that follow the substitution processes caused by a change in the world petroleum price would lead to further price changes and substitution processes. Modeling these effects would require the estimation (or fixing) of considerably more parameters and is not pursued in this paper.

in which  $\bar{\mathbf{A}}_{11}$ ,  $\bar{\mathbf{A}}_{21}$  and  $\bar{\mathbf{A}}_{13}$  are the post-substitution coefficient submatrices, indicating new quantities. The symbol  $\otimes$  stands for the Hadamard product, i.e. cell-by-cell multiplication.  $\mathbf{E}$  is a matrix of appropriate dimensions consisting of ones. The extent to which the post-substitution coefficient submatrices differ from the baseline submatrices  $\mathbf{A}_{11}$ ,  $\mathbf{A}_{21}$  and  $\mathbf{A}_{13}$  depends on two factors: the proportional change in the prices of products (contained in the diagonal matrices  $\hat{\delta}_p$ ; a value of 0.01 would represent a 1% increase of the price of the corresponding product), and the magnitude of elasticities of substitution (contained in the matrices  $\boldsymbol{\Sigma}$ ,  $\boldsymbol{\Phi}$  and  $\boldsymbol{\Theta}$ ). The typical element of  $\boldsymbol{\Sigma}$  ( $\sigma_{ij}$ ), for instance, indicates the proportional change in the use of sector  $i$ 's output following a one-percent price change for  $j$ 's output. The elasticities in  $\bar{\boldsymbol{\Sigma}} \hat{\delta}_p \mathbf{E}$ , for example, indicate the proportional change in the use of product  $i$  due to all price changes (not only the price change for output  $j$ ). These are assumed to be identical across all sectors  $k$  that use the output of  $i$ . Elements of  $\boldsymbol{\Phi}$  and  $\boldsymbol{\Theta}$  give the proportional change in the use of value added (labor and capital), and consumption of products following one-percent changes in the prices.<sup>9</sup> Appendix A gives a numerical example.

For the submatrices  $\mathbf{A}_{32}$  and  $\mathbf{A}_{33}$ , the coefficients are considered as fixed. Matrix  $\mathbf{A}_{32}$  represents the distribution of factor income on household factor endowments (see for example, Pyatt and Round, 1984). It ensures that the factor income of rural Malay employees, for example, is entirely directed to rural Malay households. This will not change with changes in relative prices. We also assume that the patterns of transfers among institutions (companies and households) remain unchanged, which is reflected in the stability of matrix  $\mathbf{A}_{33}$ .

The post-substitution coefficient submatrices in Eq. (6) give changes in quantities at original prices. They have to be multiplied with the new prices (i.e. new price levels as a result of the increase in prices of petroleum products) so that new transaction values can be derived. This yields

$$\bar{\mathbf{A}} = (\mathbf{I} + \hat{\delta}_p) \bar{\bar{\mathbf{A}}} (\mathbf{I} + \hat{\delta}_p)^{-1}.$$

A consequence, however, is that the leakage coefficients  $\mathbf{I} = (\mathbf{I} - \mathbf{A}')\mathbf{e}$  would also change. That is, they would become  $(\mathbf{I} - \bar{\bar{\mathbf{A}}}')\mathbf{e}$ . In order to prevent this and to make sure that the leakage coefficients remain the same, the columns in  $\bar{\bar{\mathbf{A}}}$  are proportionally adapted, such that the resulting matrix has the same column sums as  $\mathbf{A}$ . The new average expenditure propensities that reflect both changes in quantities and prices are given by

$$\bar{\bar{\mathbf{A}}} = \bar{\mathbf{A}} (\widehat{\mathbf{e}'\bar{\mathbf{A}}})^{-1} (\widehat{\mathbf{e}'\mathbf{A}}) = (\mathbf{I} + \hat{\delta}_p) \bar{\bar{\mathbf{A}}} (\mathbf{I} + \hat{\delta}_p)^{-1} (\mathbf{e}'(\mathbf{I} + \hat{\delta}_p) \bar{\bar{\mathbf{A}}} (\mathbf{I} + \hat{\delta}_p)^{-1})^{-1} (\mathbf{e}'\bar{\bar{\mathbf{A}}}). \quad (7)$$

The new quantity model can now be formulated as

$$\bar{\mathbf{y}}_n = (\mathbf{I} - \bar{\bar{\mathbf{A}}}_n)^{-1} \bar{\mathbf{x}} = \bar{\mathbf{M}} \bar{\mathbf{x}}. \quad (8)$$

Elasticities of substitution among intermediate inputs, factors of production and consumption of commodities as contained in the matrices  $\boldsymbol{\Sigma}$ ,  $\boldsymbol{\Phi}$  and  $\boldsymbol{\Theta}$ , respectively (see Eq. (6)). For example, substitution among production inputs is modeled in a set of nested production functions. Appendix B provides the detailed explanation of the derivation of the elasticities of substitution.

<sup>9</sup> This specification implies that we apply a linearized approximation of nonlinear substitution processes. The approximation error is small for relatively small changes in prices.

#### 4. Imposing Energy Price Shocks

In Malaysia, the domestic petroleum price is controlled and subsidized by the government under an automatic pricing mechanism. The sales tax on petroleum products is reduced to offset part of the differences between the wholesale domestic price and the world price. In our analysis, we consider the petroleum price in 2007 as a baseline for the price simulation shock. In 2007, the price of petroleum products was fixed at an average of 1.79 Malaysian ringgit (MR) per liter (average price of gasoline and diesel)<sup>10</sup> for the entire year, whereas the world price of crude oil increased by 13.1% (from 61.08 to 69.08 USD per barrel). This suggests that the government provided increasing subsidies (or a reduction of the sales tax) on petroleum products. In 2008, however, subsidies on petroleum products did not grow at the same pace as the world price of crude oil, which increased by 36.7% from 69.08 USD to 94.45 USD per barrel between 2007 and 2008 (see [Organization of the Petroleum Exporting Countries, OPEC, 2010](#)). This led to the highest domestic oil price increase in the Malaysian history, by as much as 20.7%, to 2.16 MR per liter. This is the type of price shock we will analyze.

Our price simulation involves three steps. The first step consists of calculating the price effects for the outputs of all sectors as a result of the increase in the domestic and world petroleum prices. We will assume that the world price is independent of domestic price changes. With 0.69% and 0.61% of the shares in the world market for petroleum crude oil and refineries in 2012, respectively, production of petroleum in Malaysia is too small to influence the world prices (see [Energy Information Administration, 2014](#)). In our setup, the world price for crude oil and the domestic petroleum price are treated as exogenous variables, which implies that the subsidy level is considered as endogenous. As a consequence, the price model in Eq. (5) is not appropriate, since the domestic petroleum price is determined *endogenously* in that model. To address this issue, we apply the mixed endogenous-exogenous method (see [Appendix C](#) for details with a simple numerical example of this model).<sup>11</sup>

To illustrate the mixed endogenous-exogenous price model, we first represent Eq. (3) in 3-by-3 matrix form and split the exogenous expenditure coefficients (vector  $\mathbf{a}$ ) into coefficients for imported petroleum products ( $\mathbf{m}^p$ ), a group of imported other products ( $\mathbf{m}^n$ ) and a group of other exogenous cost components ( $\mathbf{d}$ , including the sales tax, indirect taxes, savings, and investments abroad)—thus  $\mathbf{a} = \mathbf{m}^p + \mathbf{m}^n + \mathbf{d}$ . Splitting the imports requires additional data because our SAM only includes aggregated imports, presented as a single row vector in the SAM. For this purpose, the import matrix (92 products-by-92 products) included in the input-output tables ([Department of Statistics Malaysia, 2005](#)) is used to split the imports of petroleum and imports of a group of other products from the total imports. Thus, the expanded Eq. (3) can be shown as;

$$\begin{bmatrix} p_1 \\ p_2 \\ p_3 \end{bmatrix} = \begin{bmatrix} (1-a_{11}) & -a_{21} & -a_{31} \\ -a_{12} & (1-a_{22}) & -a_{32} \\ -a_{13} & -a_{23} & (1-a_{33}) \end{bmatrix}^{-1} \begin{bmatrix} m_1^p + m_1^n + d_1 \\ m_2^p + m_2^n + d_2 \\ m_3^p + m_3^n + d_3 \end{bmatrix} \quad (9)$$

Eq. (9) indicates a *fully* endogenous model. It shows that prices of sector 1 ( $p_1$ ), sector 2 ( $p_2$ ) and sector 3 ( $p_3$ ) are determined by the exogenous expenditure coefficients of  $\mathbf{m}^p$ ,  $\mathbf{m}^n$  and  $\mathbf{d}$ . In the baseline solution, the endogenous prices  $p_1$ ,  $p_2$  and  $p_3$  are equal to unity. It follows that an increase in any exogenous price or cost component increases the endogenous prices  $p_1$ ,  $p_2$  and  $p_3$ . Our study, however,

<sup>10</sup> The prices of liquid petroleum gas (LPG) remained more or less unchanged between 2007 and 2008.

<sup>11</sup> See [Miller and Blair \(2009, pp. 621–633\)](#) for a broad treatment of mixed endogenous-exogenous quantity models, and [Resosudarmo and Thorbecke \(1996\)](#) and [Hartono and Resosudarmo \(2008\)](#) for applications of such models within the context of SAM-based quantity models. We are not aware of applications of mixed endogenous-exogenous SAM-based price models.

focuses on the case in which the price for petroleum products is set exogenously. Assuming that the petroleum sector is represented by sector 3, the elements of Eq. (9) need to be re-arranged. As a result of this manipulation, we obtain,

$$\begin{bmatrix} p_1 \\ p_2 \\ p_3 \end{bmatrix} = \begin{bmatrix} (1-a_{11}) & -a_{21} & 0 \\ -a_{12} & (1-a_{22}) & 0 \\ -a_{13} & -a_{23} & -1 \end{bmatrix}^{-1} \begin{bmatrix} m_1^p + m_1^n + d_1 + a_{31}p_3 \\ m_2^p + m_2^n + d_2 + a_{32}p_3 \\ m_3^p + m_3^n - (1-a_{33})p_3 \end{bmatrix} \quad (10)$$

Eq. (10) consists of four exogenous parts, i.e. the domestic petroleum price ( $p^3$ ), the world petroleum price (affecting the costs  $\mathbf{m}^p$ ), the costs of non-petroleum imports ( $\mathbf{m}^n$ ) and other exogenous costs ( $d_1$  and  $d_2$ ). These determine three endogenous prices: the prices of the domestic non-petroleum products 1 and 2, and the other costs per unit of output of domestic petroleum ( $d_3$ ). In our simulation, prices of domestic petroleum ( $p_3$ ) and the costs of imported petroleum ( $\mathbf{m}^p$ ) increase by 20.7% and 36.7%, while the other exogenous components (i.e. the elements of  $\mathbf{m}^n$  and  $d_1$  and  $d_2$ ) remain fixed. It is important to note that an increase in the price of imported petroleum would not only affect the petroleum sector but also other sectors that consume imported petroleum, unless it would be offset by a change in the fuel subsidy.

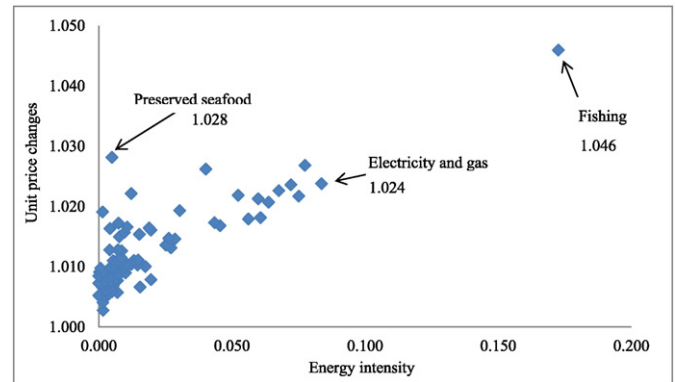
In the second step, the increases in the prices of all sectors along with the imposed substitution elasticities are used as variable inputs into Eqs. (6) and (7) so that a new set of average expenditure propensities matrix,  $\bar{\mathbf{A}}$  is produced. Finally, we use (8) to measure the extent to which substitution effects have implications for the income distribution under the assumption that exogenous income levels,  $\mathbf{x}$ , remain unchanged.

#### 5. Results and Discussion

This section mainly discusses the extent to which rising petroleum prices affect income and inequality in per capita income among the major ethnic groups in Malaysia.

##### 5.1. Price Effects

According to the price model of Eq. (10), the rising prices of domestic and imported petroleum products have modest implications on prices of other sectors, with increases ranging from 0.28% for the household machinery sector to 4.6% for the fishing sector. [Fig. 1](#) clearly shows that price responses are generally strongest for energy-intensive industries. The energy intensities are defined as cost shares of energy (crude and refined petroleum products) in total output.



Sources: computed from the social accounting matrix (see [Saari et al., 2014](#))

**Fig. 1.** Correlation between changes in price and energy intensity.

Sources: computed from the social accounting matrix (see [Saari et al., 2014](#)).

**Table 4**

Income and per capita income effects of changes in petroleum price.

		Rural Malays	Rural Chinese	Rural Indians	Rural others	Urban Malays	Urban Chinese	Urban Indians	Urban others	Non-citizen
<i>A. Effects of rising petroleum price</i>										
<i>A1. Nominal income effects</i>										
Baseline income (in MR million)	(1)	25,396	10,161	3907	4554	40,514	47,360	10,412	3892	9844
Nominal income after price shock (in MR million)	(2)	25,946	10,265	3944	4602	41,108	47,988	10,563	3931	9931
Change in nominal income (in MR million)	(3)	550	104	36	47	595	627	150	39	88
Change in nominal income (in %)	(4)	2.16	1.02	0.93	1.04	1.47	1.32	1.45	1.00	0.89
<i>A2. Real income effects</i>										
Change in index cost of living (in %)	(5)	3.68	1.45	1.29	1.65	3.28	2.27	2.69	1.52	1.63
Real income after price shock (in MR million)	(6)	25,012	10,118	3893	4526	39,780	46,913	10,282	3872	9772
Change in income (in %) <sup>a</sup>	(7)	−1.51	−0.42	−0.36	−0.62	−1.81	−0.95	−1.25	−0.52	−0.73
<i>A3. Per capita income effects</i>										
Distribution of population (in %)	(8)	35.37	7.49	2.89	2.16	23.28	20.33	5.37	0.93	2.18
Distribution of baseline income (in %)	(9)	16.28	6.51	2.50	2.92	25.96	30.35	6.67	2.49	6.31
Distr. of real income after price shock (in %)	(10)	16.22	6.56	2.53	2.94	25.80	30.43	6.67	2.51	6.34
Change in distribution (in %-points)	(11)	−0.05	0.05	0.02	0.02	−0.16	0.08	0.00	0.02	0.03
<i>B. Effects of declining petroleum price</i>										
Change in nominal income (in %)	(12)	−9.81	−8.93	−5.38	−5.00	−8.39	−9.58	−8.61	−5.83	−6.79
Change in index cost of living (in %)	(13)	−6.92	−2.66	−2.37	−3.05	−6.15	−4.21	−5.02	−2.80	−3.00
Distr. of real income after price shock (in %)	(14)	16.43	6.34	2.52	2.97	26.38	29.85	6.69	2.51	6.31
Change in distribution (in %-points) <sup>b</sup>	(15)	0.15	−0.17	0.02	0.06	0.41	−0.50	0.01	0.02	0.00

Sources: computed from the social accounting matrix (Saari et al., 2014)

Notes: (a) percentage difference between real income after the price shock (row 6) and the baseline income (row 1) and (b) percentage difference between row 14 and row 10.

Higher petroleum prices (both domestic and foreign) affect the producers' costs through two channels. First, there is a direct effect from an increase in the price paid by producers for the consumption of petroleum products inputs. According to Fig. 1, the price of fishing products increases most strongly (by 4.6%). This is because energy consumption for this sector is the highest among all sectors and amounts to 17.3% of its total costs (including profits and other compensation for the use of capital). Second, there is an indirect effect from the use of non-energy inputs, the prices of which are increased to offset the increase in their energy costs. This indirect effect explains why some sectors which are not extremely energy intensive themselves still experience substantial increases in their costs of production. Preserved seafood is an example of such a sector. Not surprisingly, preserved seafood's most important inputs (49.8% of the costs) come from the energy-intensive fishing industry, while the cost share of petroleum products amounts to only 0.5%.

## 5.2. Income Effects

Next, we derive the new matrix of average expenditure propensities, taking the changes in prices and substitution elasticities into account. Using these new average expenditure propensities and given the current exogenous income levels, we calculate the impacts on income across ethnic groups. The results are summarized in Table 4, which contains results in both nominal and real terms. Panels A1 and A2 of Table 4 provides the nominal income and real income effects of rising petroleum prices. Rows 1 and 2 show the baseline income levels and the estimated income levels after the price shock, respectively. Rows 3 and 4 give the changes between the baseline and the post-price shock income levels in millions of MR and in percentages, respectively.

It is not very useful to assess the effects of the changes in prices on inequality on the basis of nominal income effects. Nominal income effects do not take increases in the cost of living due to higher energy prices into account. Given the percentage price changes of consumer items and given the different consumption patterns among ethnic groups, changes in real income caused by higher petroleum prices should be used instead. The real income effects can then be calculated by taking the difference between the changes in the nominal income (in row 4) and the changes in consumer price index (in row 5). The

results for the real income effects are tabulated in row 6. Row 7 gives the percentage change in real income compared with the initial income.

The variations in the changes in the nominal income effects and consumer price index effects determine the distribution of real income. The results indicate that rising petroleum prices have modest positive effects on nominal household income, of 1.43% on average. The positive effect is due to the fact that our price model assumes that higher product prices lead to higher wage rates. The observation that changes are not too substantial is comparable with other studies that impose substitution effects in Leontief models. Kratena (2005), for example, who modeled substitution effects by means of a generalized Leontief function for aggregated labor and intermediate inputs, observed that the differences in output effects between the price-induced model and the fixed input coefficient model were 0.20% on average. In our study, the differences in output (in nominal terms) are also small at 0.24% on average.

The relative income effects for the individual household group in rural and urban areas differ to some extent. Rising petroleum prices causes a growth of nominal income for rural households of 1.67% while the corresponding increase of urban income amounts to 1.38%. The changes in nominal incomes of households belonging to the various ethnic groups are also not identical. The growth of nominal income is benefitted the Malays the most compared to the Chinese and Indians. In rural areas, the growth of nominal income for the Malays is 1.14% and 1.23% larger than the Chinese and Indians. In urban areas, the differences are marginal which deviate only by 0.15% and 0.02%. Recall that in our modeling approach, elasticities of substitution are imposed based on the Cobb-Douglas function, which implies that rising the petroleum prices leads to the substitution of other inexpensive intermediate inputs, labor and capital. We observe that the increase in petroleum prices induce demand for labor and capital inputs by 1.5% and 0.3% on the average while demand for intermediate inputs declines by −0.2%. For the labor, the demand for the Malay labors is 2.0% and 2.1% higher than the Chinese and Indians in rural areas while it enlarges only 0.4% and 0.1% in urban areas. This explains the variation in the nominal income growth across the ethnic groups.

To account for the real income effects, the nominal income is adjusted for the change in consumer price index, which is given in row 5. The consumer price index measures the cost of acquiring the baseline basket of goods, before and after the price shock. Data on the



baseline expenditure patterns of the individual ethnic groups in rural and urban areas are available in our SAM and have been used for the calculation. To estimate the new level of expenditure, the initial consumption expenditures of each ethnic group is multiplied with the increased prices (as caused by the energy price rises). The weights (consumption expenditure shares of products) vary across ethnic groups. The percentage difference between the estimated value of the consumption bundle and the baseline value then gives the change in the consumer price index.

For all household groups, the increase in consumer price index appears to be larger than nominal income growth, which implies erosion of real income levels. Income losses (averaged over households in each of the nine groups) vary roughly between 0.36% and 1.81%. Households in urban areas suffer slightly more than households in rural areas. On average, real income levels of rural households decline by 1.08%, while those of urban households decline by 1.32%. The decline in real incomes due to the rise in the prices of petroleum products is the largest for Malay households than for other ethnic groups. The declines are particularly sizable in the urban areas. There, the expected percentage erosion in real income for Malays is about a full percentage point larger than for households of Chinese and Indian ethnicity.

The variation in the increase in consumer price index, which is much larger for Malays than for other ethnic groups, depends on the relative shares of petroleum products and petroleum-intensive products in their consumption bundles. For the ethnic Malays, the data in our SAM show that the direct consumption shares of petroleum products are much larger than for other groups, 11.9% and 13.3% points larger than the Chinese and Indians in rural areas and 5.2% and 3.3% points larger in urban areas. For the indirect consumption of non-energy products, differences are mainly large for outputs of sectors of which prices are least affected by the higher petroleum prices. Differences in consumption for the non-energy products of which prices are most strongly affected by the higher petroleum prices such as preserved seafood, oils and fats, and clay products are marginal. Thus, we find that the direct consumption of petroleum products is responsible for the higher increase in consumer price index for Malay households.

Panel A3 of Table 4 tabulates the distributional impacts of higher petroleum prices. Row 8 gives the shares of each of the nine household groups in the Malaysian population as a reference point (see Department of Statistics Malaysia, 2001a,b). Row 9 shows that the baseline income distribution is not too different from the population distribution, with two major exceptions: the income share of rural Malays is much lower than its population share, while the urban Chinese have a considerably higher share in income than in population.<sup>12</sup> In row 10, the distribution of real income after the price shock is given. The change between the baseline distribution and the distribution of estimated real income is given in the bottom row 11. The results show that the distributional impacts of rising petroleum prices are regressive with smaller in magnitude. The rural Malays (who already have relatively low incomes) are among the groups that face a decline in their share of the pie by 0.05%. The urban Malays, however, lose a little bit more by 0.16%. The urban Chinese households, who have on average higher incomes than any other household group apart from the small non-citizens and a group of other minority ethnics gain about 0.08%.

Panel B of Table 4 presents the simulation results for the distributional impacts of decreasing petroleum price. Recall that the world price of crude oil dropped in 2015 to about 44.5% of its 2008 level, to reach 52.43 USD per barrel. This is very close to the 2005 price level (50.64 USD, see Table 1). Hence, we take the world price of crude oil in 2005 as a benchmark for our simulation. In this scenario, the average domestic petroleum prices are expected to decrease by 37.5%, from 2.16 MR in 2008 to the 2005 level of 1.35 MR. Although the world price of

crude oil decreased by 44.5%, the depreciation in the exchange rate (MR/USD)<sup>13</sup> between 2015 and 2005 implies that the import costs are 0.5% higher than the 2005 level. Taking this into consideration, the world price of crude oil is expected to be reduced by 44%. We repeat the similar methodological approaches for this additional simulation by running Eq. (10) for the price effects and Eqs. (6)–(8) for the income effects. The results in Panel B show that falling oil prices affect the real income stronger than the case of increasing oil prices. This can be explained by the magnitude of the price changes in our simulation. That is, the changes (in an absolute sense) in the domestic and world oil prices for the case of falling oil prices are 16.8% and 7.3% higher than in the simulation of increasing prices.

The results in Panel B confirm our earlier argument in Section 1 that the distributional impacts of decreasing petroleum prices are progressive. There is a shift in distribution of real income in favor of the Malays, Indians and Others at the expense of the Chinese. The real income share of the Malays improves by 0.15% in rural and 0.41% in urban areas. The improvement in income share for rural Indians is 0.01% higher than for urban Indians. For the Others, the effects are strongest in rural areas. For the Chinese, declines in real income share are more substantial in urban areas than in rural areas. Although declining petroleum price improves the income inequality between the ethnic groups, the improvement is obtained at the expenses of reduction in real income for all ethnic groups.

## 6. Concluding Remarks

This paper examines how the incomes of various ethnic groups in Malaysia are affected by a major change in the domestic price of petroleum products, caused by large jumps in the world price for crude oil, and the decision by the Malaysian government not to fully compensate this by an increase in the subsidies for petroleum products. This is a situation faced by the country in 2008. In our analysis, distributional impacts of rising and declining petroleum prices are measured. In both situations, changes in nominal income levels (due to price propagation of inflation into wages) and changes in the cost of living are taken into account. On one hand, our results show that the distributional impacts of rising petroleum prices tend to be regressive. That is, the lowest income groups (of ethnic Malays) bear the highest burden and the highest income groups (mainly households of Chinese ethnicity living in cities) suffer least. On the other hands, the distributional impacts of declining petroleum prices are progressive. The real incomes for all household groups reduce with the lowest income groups are less affected compared to the highest income groups. Thus, although price deregulation through subsidy rationalization implies fiscal benefits, it must be evaluated carefully and, if deemed needed, be supplemented with measures to compensate for further deteriorations in the income distribution.

The results of this study have been obtained by running a novel price-induced SAM model that allows some degree of substitutability among production inputs and products for consumption. Two shortcomings should be mentioned. First, the results can be sensitive to the choice of the elasticities of substitution. Due to scarce data, we adopted functional forms of production and consumption functions that completely fix these elasticities. If extensive data would have been available, more sophisticated estimation methods could have been used. Second, the presented model is still considered as a partial model. The average expenditure propensities are adjusted when relative prices change, but these adjustments only reflect the first round effects. Second round effects would consider changes of prices due to the changes in quantities caused by substitution effects. Next, these second round price changes cause substitution effects, etc., until equilibrium is attained. Computable general equilibrium (CGE) models capture the full

<sup>12</sup> Other major differences are only observed for small groups, i.e. the urban "others" and the non-citizens.

<sup>13</sup> The exchange rate in 2005 is 3.79 MR per USD and the average exchange rate from January to October 2015 is 3.81 MR per USD.

price and quantity feedbacks but require the estimation of many more parameters. For the purposes of this paper (which requires both data for various population groups and for various production sectors) and in the context of data availability for an economy like that of Malaysia, the novel model introduced in this study seems to be an appropriate choice.

#### Appendix A. Numerical example for the effects of substitution on coefficient matrices

Consider the case of two products and let the following matrices be given.

$$\Sigma = \begin{bmatrix} -0.8 & 0.6 \\ 0.4 & -1.0 \end{bmatrix}, \hat{\delta}_p = \begin{bmatrix} 0.01 & 0 \\ 0 & 0.02 \end{bmatrix}, E = \begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix}$$

The price of product 1 increases with 1% (as shown in  $\hat{\delta}_p$ ) and as a consequence the use of product 1 decreases with 0.8% and is partly substituted for product 2, the use of which increases with 0.4%. In the same fashion, the price of product 2 increases with 2%. Every %-increase in price of product 2 decreases its use by 1.0% and increases the use of product 1 by 0.6% due to substitution. The price increase of 2% for product 2 thus reduces its use with 2% and increases the use of product 1 with 1.2%. This is reflected by

$$\Sigma \hat{\delta}_p = \begin{bmatrix} -0.008 & 0.012 \\ 0.004 & -0.020 \end{bmatrix}.$$

The exogenous price increases of products 1 and 2 occur simultaneously so that the use of product 1 increases with  $-0.008 + 0.012 = 0.004$  and the use of product 2 decreases (i.e. its change is  $0.004 - 0.020 = -0.016$ ). The change in the use of product 1 is assumed to apply to any use, i.e. the firms producing products 1 and the firms producing product 2. The changes in the input coefficients are then given by

$$\Sigma \hat{\delta}_p E = \begin{bmatrix} 0.004 & 0.004 \\ -0.016 & -0.016 \end{bmatrix}.$$

If the input coefficients matrix  $A_{11}$  is given by

$$A_{11} = \begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{bmatrix}.$$

The new coefficients become

$$A_{11} \otimes (E + \Sigma \hat{\delta}_p E) = \begin{bmatrix} \alpha_{11} \times 1.004 & \alpha_{12} \times 1.004 \\ \alpha_{21} \times 0.984 & \alpha_{22} \times 0.984 \end{bmatrix}.$$

#### Appendix B. Nested production functions

In what follows, we present the determination of the elasticities of substitution among intermediate inputs, factors of production and consumption of commodities that contained in the matrices  $\Sigma$ ,  $\Phi$  and  $\Theta$ , respectively (see Eq. (6)). Substitution among production inputs is modeled in a set of nested production functions, which is summarized in Fig. B.1. For each industry, such a nested production structure is specified.

In the top nest, gross output ( $Y$ ) is modeled as a Cobb-Douglas function with three inputs, i.e. factors of production (which generate value added,  $Q$ ), petroleum ( $E$ ) and intermediate inputs (domestic and imported,  $M$ ):  $Y = A Q^{\alpha} E^{\beta} M^{\lambda}$ . This is a common specification that reflects the assumption that these three classes of inputs can substitute for each other. If stages of production processes are outsourced to other industries, own production factors are saved, while the use of intermediate inputs increases. Changes in relative wages of own workers and of workers in other industries are known to be a driver of such outsourcing decisions. Furthermore, changes in the price of petroleum products can induce switches from petroleum to other (energy or non-energy) inputs. Cobb-Douglas production functions allow for such substitution effects. They imply a unitary elasticity of substitution between any pair of inputs. This implies that cost shares of inputs remain constant because any change in input prices will be exactly offset by an equally large but opposite change in the quantity used. Substitution among inputs in this nest feeds into  $\bar{A}_{11}$  and  $\bar{A}_{21}$  in Eq. (6).

The imposed unitary elasticity of substitution might be seen as very restrictive. The use of more flexible production functions (such as constant elasticity of substitution or translog production functions) would

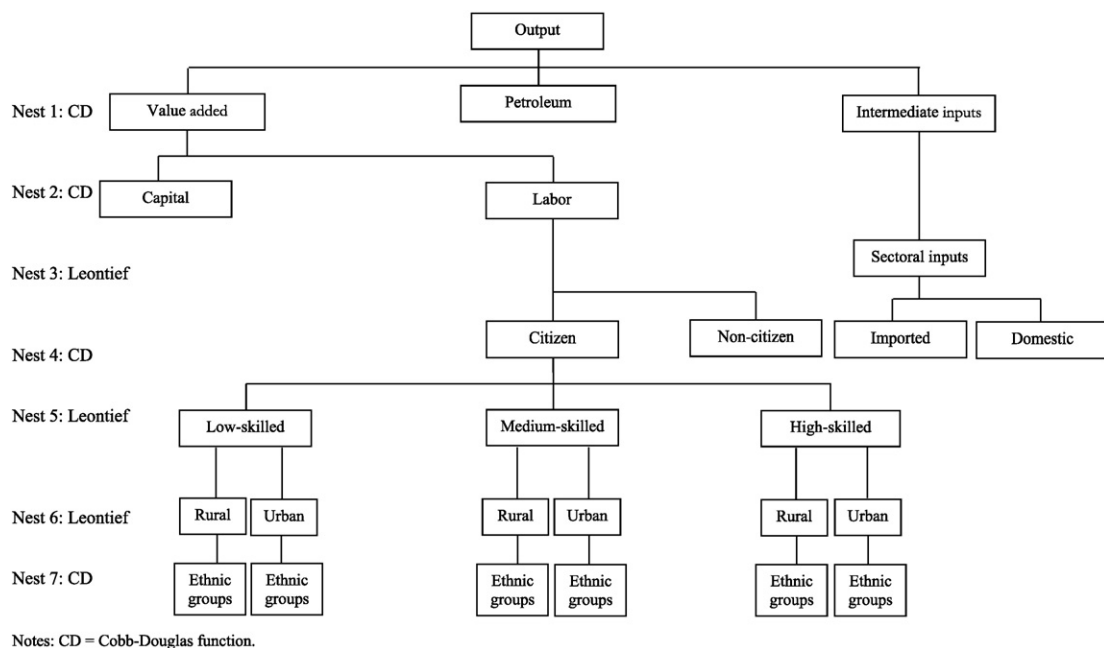


Fig. B.1. The nested structure of the production functions.

require econometric estimation procedures for which data are lacking in the context of the present study. Data on detailed input components (such as labor, capital, energy and non-energy materials) are not only available with limited coverage (i.e. only available for 17 manufacturing sectors and not for services sectors) but our focus on sector-level data also leads to an insufficient number of observations.<sup>14</sup> In addition, a number of empirical estimates find that elasticities of substitution are often not significantly different from unity, suggesting that the Cobb-Douglas serves as a reasonable working hypothesis. An example of such a study is Duffy and Papageorgiou (2000), who show that unitary elasticities are empirically plausible for developing countries like Malaysia.

To derive the matrix  $\bar{A}_{11}$ , pairwise elasticities of substitution for all intermediate inputs are required, but the elasticities derived from the first nest relate to the aggregated level only. The following approaches are taken as alternatives to the lack of data required to estimate elasticities of substitution for individual intermediate inputs. First, it is common in applied general equilibrium analysis to split the total demand for intermediate inputs ( $M$ ) by sector-of-origin using Leontief production technologies (see for example, Kratena, 2005; Welsch and Ochsen, 2005). This assumption implies that substitution among intermediate inputs is not possible at all. A quantity of a specific input should always be used in combination with fixed quantities of other inputs, irrespective of changes in relative prices. For short-run analyses, this assumption for Nest 3 is not very restrictive. Second, disaggregation of the each sectoral intermediate input into domestically produced and imported inputs is modeled using a Cobb-Douglas function in nest 4:  $M = AM_D^{\phi} M_M^{\phi}$ , in which  $M_D$  and  $M_M$  are domestic and imported intermediate inputs, and  $\kappa$  and  $\phi$  are parameters. Domestic inputs that become more expensive are assumed to get used less intensively, while the use of imported inputs increases (*ceteris paribus*). Again, the elasticity of substitution is fixed at one. For highly degree of trade openness country like Malaysia, modeling the Cobb-Douglas function for substitutability between domestic and imported intermediate inputs is plausible (in 2002, indicator for openness that measured by a ratio of total trade (export plus import) to GDP is 2.07).

For matrix  $\bar{A}_{21}$ , the elasticity of substitution for the factors that (taken together) produce aggregate value added can be derived from further disaggregating the value added generating production factors from Nest 1. First, in Nest 2, the uses of physical capital ( $K$ ) and aggregate labor ( $L$ ) inputs are modeled as a Cobb-Douglas function,  $Q = AK^{\alpha} L^{\beta}$ . In Nests 4 to 7, the aggregate labor input is split up into labor classified by citizenship status, skill level, geographical location and ethnic group. A Cobb-Douglas function is used to disaggregate labor inputs by citizen ( $L_L$ ) and non-citizen ( $L_F$ ) workers in Nest 4, which is defined as  $L = AL_L^{\gamma} L_F^{\gamma}$ .

In Nest 5, a Leontief technology is assumed to split employment of citizens according to three skill types—low ( $L_{LL}$ ), medium ( $L_{LM}$ ) and high ( $L_{LH}$ ), assuming that these are hard to substitute for each other.<sup>15</sup> Demand for each of these skill types can be represented by  $(L_{LL}, L_{LM}, L_{LH}) = (w_{LL} L_L, w_{LM} L_L, w_{LH} L_L)$ . The demand for skills is proportionally fixed to labor inputs aggregated over skill types (e.g.  $w_{LL} = (L_{LL}/L_L)$  for low skilled). In Nest 6, a similar no-substitution assumption is made to model the split of labor inputs for each of the skills between workers from rural and urban areas. For example, demand for rural-low skilled ( $L_{LL}^R$ ) and urban-low skilled ( $L_{LL}^U$ ) labors can be denoted as  $(L_{LL}^R, L_{LL}^U) = (w_{LL}^R L_{LL}, w_{LL}^U L_{LL})$ , where the rural low-skilled and urban low-skilled workers are fixed proportionality of low-skilled ( $w_{LL}^R, w_{LL}^U = (L_{LL}^R/L_{LL}, L_{LL}^U/L_{LL})$ ). Finally in Nest 7, workers in rural and urban areas across

all skill types are split up into ethnic groups, i.e. Malays ( $E_B$ ), Chinese ( $E_C$ ), Indians ( $E_I$ ) and others ( $E_O$ ), using a Cobb-Douglas function. For example, we can model for rural low-skilled labor ( $L_{LL}^R$ ) as  $L_{LL}^R = AE_B^{\theta} E_C^{\theta} E_I^{\theta} E_O^{\theta}$ . We thus assume that substitution between workers of different ethnicities is possible.

Modeling substitution among consumption of commodities using flexible and widely applied functional forms such as the generalized Leontief (see Diewert, 1973), the translog (see Christensen et al., 1975) and the “almost ideal demand system” (see Deaton and Muellbauer, 1980) is also impossible due to limited data availability. The household expenditure survey (HES) that is published every 5 years provides rich data on the consumption of commodities by individual household, but does not include price data. Also, time-series data for consumption is available in Malaysia but not in disaggregated form (neither by type of commodities nor by groups of households). Given these constraints, Cobb-Douglas and Leontief functions are the natural options to choose from. Given that cross-country evidence suggests that the magnitude of elasticity of substitution between consumption of different commodities is below 0.5 (see Regmi and Seale, 2010; Clements, 2008), the Leontief function with zero substitution is perhaps the most plausible choice (Deaton and Muellbauer, 2007). Thus, using the Leontief function, demand for product  $i$  by each household group  $k$  ( $k$  = Malays, Chinese, Indians and others in rural and urban areas, and non-citizen) can be modeled as  $k(c_i, \dots, c_n) = (z_i c_i, \dots, z_n c_n)$ , in which  $z_i = (c_i/C_i)$  is the fixed consumption share for product  $i$  in total consumption.

Since econometric estimation of parameters in the nested production function framework adopted in the previous section is impossible due to lack of observations, we calibrate the parameters. In the context of this paper, calibration boils down to pinning down the variables at the values that are observed in our SAM. We use a SAM for Malaysia for 2000, which was briefly discussed in Section 3 (see Saari et al., 2014, for details) and is the most recent one available for Malaysia. Setting price variables equal to unity for that table, the quantity variables are simply equal to the corresponding values in the SAM (see Hosoe et al., 2010, for an overview of calibration methods). This calibration method may not provide perfect estimation of the parameters because it relies on data for a single year, which means that whatever stochastic anomalies were present in that year will influence the model. Nevertheless, as mentioned in the previous section, an insufficient number of observations and lack of data justify our choice for this method.

### Appendix C. Numerical example of a mixed endogenous-exogenous price model

This example gives a simple numerical illustration of mixed endogenous-exogenous multipliers for a simplified SAM price model,

**Table C.1**  
Stylized SAM.

	Transactions (RM billion)			Coefficients ( $\mathbf{A}$ and $\mathbf{a}$ )		
	Agr	Man	Pet	Agr	Man	Pet
Agriculture (Agr)	6.04	0.00	34.46	0.11	0.00	0.02
Manufacturing (Man)	0.00	0.09	35.66	0.00	0.00	0.02
Petroleum (Pet)	10.83	15.48	627.02	0.20	0.18	0.43
Imported petroleum products ( $m^p$ )	3.00	3.00	244.00	0.05	0.03	0.17
Imported non-petroleum products ( $m^n$ )	1.15	1.20	100.54	0.02	0.01	0.07
Taxes ( $t$ )	0.85	0.08	11.23	0.02	0.00	0.01
Value added ( $d$ )	33.19	67.05	409.03	0.60	0.77	0.28
Total primary input ( $a$ )	38.19	71.33	764.80	0.69	0.82	0.52
Total input	55.07	86.90	1461.94	1.00	1.00	1.00

Notes: primary input consists of imported commodities (petroleum and non-petroleum products), indirect taxes and value added.

<sup>14</sup> Modeling the translog function with four inputs (energy, capital, labor and intermediate inputs) in three equations gives 12 coefficients (including a constant) to be estimated in a system of equations (see Berndt and Wood, 1975).

<sup>15</sup> This is supported by the facts that skilled and unskilled labors are imperfect substitutes (see, for example, Welsch and Ochsen, 2005; Berndt and Morrison, 1979).



as introduced in Section 4. The notation used in this appendix is specific for this example and may differ from the notation in the main text.

Let us consider the SAM flows in Table C.1 and coefficients derived from it.

For each sector, exogenous costs ( $a$ ) consist of imports of petroleum products ( $m^p$ ) and imports of non-petroleum products ( $m^n$ ), taxes/subsidies ( $t$ ) and value added ( $d$ ). The solution for the price model is represented by the following matrix form

$$p = (I - A')^{-1} a \quad (C.1)$$

where  $a$  reflects the exogenous costs per unit of output (in Table C.1 under coefficients). In the context of the economy described by Table C.1, Eq. (C.1) can be represented in partitioned form:

$$\begin{bmatrix} p_1 \\ p_2 \\ p_3 \end{bmatrix} = \begin{bmatrix} (1-a_{11}) & -a_{21} & -a_{31} \\ -a_{12} & (1-a_{22}) & -a_{32} \\ -a_{13} & -a_{23} & (1-a_{33}) \end{bmatrix}^{-1} \begin{bmatrix} m_1^p + m_1^n + t_1 + d_1 \\ m_2^p + m_2^n + t_2 + d_2 \\ m_3^p + m_3^n + t_3 + d_3 \end{bmatrix} \quad (C.2)$$

In both equations, the variables on the left hand side are considered as endogenous. The prices of agriculture ( $p_1$ ), manufacturing ( $p_2$ ) and petroleum ( $p_3$ ) sectors are determined by exogenous cost components. The empirical analysis in Section 4, however, requires us to treat the price of domestic petroleum ( $p_3$ ) as exogenous variable, since it is a target variable for the government. Since the government cannot affect the prices of imports, one may choose the taxes/subsidies on product 3 ( $t_3$ ) as an endogenous variable. Eq. (C.2) can then be re-arranged as follows,

$$\begin{bmatrix} p_1 \\ p_2 \\ t_3 \end{bmatrix} = \begin{bmatrix} (1-a_{11}) & -a_{21} & 0 \\ -a_{12} & (1-a_{22}) & 0 \\ -a_{13} & -a_{23} & -1 \end{bmatrix}^{-1} \begin{bmatrix} m_1^p + m_1^n + t_1 + d_1 + a_{31}p_3 \\ m_2^p + m_2^n + t_2 + d_2 + a_{32}p_3 \\ m_3^p + m_3^n + d_3 - (1-a_{33})p_3 \end{bmatrix} \quad (C.3)$$

Let us assume that the domestic price of petroleum ( $p_3$ ) increased by 10% (thus  $p_3 = 1.10$ ) and the price of imported petroleum grew by 15% (implying that the costs of these imported inputs are multiplied by 1.15). Given the information available in Table C.1,  $(I - A')$ ,  $(I - A')^{-1}$  and  $a$  contain the following values

$$(I - A') = \begin{bmatrix} 0.89 & 0.00 & 0.00 \\ 0.00 & 1.00 & 0.00 \\ -0.02 & -0.02 & -1.00 \end{bmatrix}; (I - A')^{-1} = \begin{bmatrix} 1.12 & 0.00 & 0.00 \\ 0.00 & 1.00 & 0.00 \\ -0.03 & -0.02 & -1.00 \end{bmatrix}$$

$$a = \begin{bmatrix} (0.05 \times 1.15) + 0.02 + 0.02 + 0.60 + (0.20 \times 1.10) \\ (0.03 \times 1.15) + 0.01 + 0.00 + 0.77 + (0.18 \times 1.10) \\ (0.17 \times 1.15) + 0.07 + 0.28 - (1 - 0.43) \times 1.10 \end{bmatrix}$$

The solution for this mixed endogenous-exogenous model would be

$$\begin{bmatrix} 1.031 \\ 1.023 \\ 0.038 \end{bmatrix} = \begin{bmatrix} 1.12 & 0.00 & 0.00 \\ 0.00 & 1.00 & 0.00 \\ -0.03 & -0.02 & -1.00 \end{bmatrix} \begin{bmatrix} 0.92 \\ 1.02 \\ -0.09 \end{bmatrix} \quad (C.4)$$

This numerical example shows that 10% and 15% increase in prices of domestic and imported petroleum products leads to the increase in prices of agricultural products by 3.1%, and of manufacturing products by 2.3%. The difference is largely due to the fact that inputs of petroleum per unit of agricultural output are higher than for manufacturing output. The tax per unit of output in the petroleum industry increase from 0.01 to 0.038. Just from a cost perspective, the rise in the price of domestic petroleum could have been much less than 10%. The gap between revenues and costs of the domestic petroleum sector goes in this example entirely to the government in the form of an increased sales tax rate on domestic petroleum products.

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